

## **Re-defining Research**

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## **Revealing Textile Knowledge through Interdisciplinary Research**

This paper describes how an interdisciplinary group of practitioners and researchers are working across schools at NTU in the area of technical textiles. It introduces the strands of ongoing enquiry centred around the development and application of stretch sensors on the body, focusing on the contribution of textile knowledge to the process.

Two years ago, the University invested in the appointment of a number of interdisciplinary research fellows whose explicit role was to undertake and facilitate research across schools and disciplines, creating new hybrid knowledge and opportunities for external research funding. As a result of this vision, there now exists a growing community of interest in the fields of technical textiles, wearable technology and physical computing, with works-in-progress and early outcomes being exhibited and published internationally. The team includes a number of different textile specialists, who have worked closely with a fit expert to develop design processes for embedding stretch sensing into garments.

The initial aims of the project were to make use of such textile knowledge in the application of stretch sensing in product design, to introduce textile practitioners to the principles of interaction design, and to build new skills in working with electronics. However, one of the most important emerging outcomes of the collaborative work has been an increased critical reflection on what textile knowledge is, and how it might be articulated not only for such interdisciplinary research, but in the reflexive awareness of the discipline itself. This paper is an attempt to articulate this fragile understanding, found in the 'making strange' of otherwise familiar practice. It covers the textile and fashion specialisms of embroidery, knit, weave, and pattern cutting.

### **Key Words**

Interdisciplinary research, embodied knowledge, communities of practice, wearable technology, stretch sensing, pattern cutting, seams, seamfulness, craft

## Introduction

In 2008, the role of Interdisciplinary Research Fellow in Technical Textiles was created with the strategic aim of facilitating a community of research comprising Textile Design and Product Design specialisms. This was to be focused on the commercially available stretch sensor marketed by Merlin Robotics Systems, which had not yet featured in published academic research. On the simplest level this reflected mutually recognised values and needs of the two originating disciplines: technology led product design realised the power of a well considered aesthetic design, while the textiles researchers were keen to gain skills in electronics to enable further ideation. This structure was put in place explicitly to generate new and unpredictable networks of knowledge by introducing these two meta-disciplines to new communities of research through the Research Fellow. These have included Interaction Design and Wearable and Tangible Computing. In expecting the textiles specialists in the project to take ownership of collaborative work being presented to unfamiliar audiences in these fields, however, it has emerged that there needs to be a fundamental deconstruction and reconstruction of meaning in practice. This means that in effect the team have been exploring the creation not only of new hybrid skills and methods, but also of design methodology itself; subsequently, if this paper presents the application of an existing research method at all, it is that of Craft, discussed in the following section.

The materiality of a system's inputs and outputs have become concerns of both interaction design theory and critical wearables practice (Hallnäs & Redström 2006, Orth 2001), while *purpose* in design has been brought into question in the wearables literature, with many functionality led projects criticised for being opportunistic or lacking in aesthetic consideration (Berzowska 2005). In 2001, one of the leading advocates of wearable computing, Professor Thad Starner, wrote that the wearables design process may in fact benefit from being 'turned upside down', starting with expression rather than function, in order to fully exploit the rich embodied knowledge of other disciplines (2001). The work of Lars Hallnäs, Johan Redström and others at the Interactive Institute, PLAY Research Studio approaches ubiquitous technologies in terms of "what it means for something to be present in someone's life" at a metaphorical level, as opposed to through definitions of use (Hallnäs & Redström 2002, p.106, Redström 2006). In Evans' words, the work should seek to overcome "our present day lack of sensibility – our competence to join beauty with practicality", and so bypass the notion of craft as nostalgic (1998, p.46), creating instead instruments "made for hands by hands" (1998, p.53). This paper proposes that some of the difficulties in designing for presence as opposed to function can be overcome through a combination of the protocols on craft practice with Hallnäs and Redström's approach: "if we think about the material that forms the expressions of computational things, it is clear that it is a combination of computations and interaction surfaces. Clearly, 'aesthetical design' of computational things is not to give a computer a new and more colourful shell" (2002, p.117).

## **Craft as a methodology for interdisciplinary design research**

Craft, especially in its critically aware contemporary form, provides a valuable model for the design of computational wearables that exhibit presence as defined by Hallnäs and Redström. Contemporary Craft seeks to dissolve dichotomies of planning and situation, of mind and body, of expert and layman, of process and product. As a methodology it involves many inversions of standard design thinking, perhaps most obviously that *design solves problems*. This approach rather acknowledges the crucial role of problems in people's creative systems of meaning making and experience which become embodied as presence (Kettley 2007). It presents craft as a serious discipline with the potential to inform new practice and goes beyond the common conceptions of craft as a thing well done, and even beyond its traditionally close relationship with material. In fact, this is a new configuration for craft in that it deliberately aims to delineate any design principles at all. Bearing this in mind, the methodology rests on the claim that *the embodied nature of the making process invites an embodied response from the viewer*. That is, both are exploratory, and both create meaning through action. These principles have underpinned both the experimental approach of the textile practitioners in this project, and of the Research Fellow in her understanding of the emergence of the Technical Textiles research cluster itself (Kettley 2007):

- o the risky non-predetermined process results in original visual language, seen to embody particular political and metaphorical values
- o 'material' may include traditional materials, technologies, processes and methods, each having their own affordances and constraints
- o internalization of material – both source material and the material being worked – is essential for the development of original visual language
- o this internalization is achieved through action – techniques include drawing, direct manipulation of material, and repeated exposure to the material
- o control over formal expressive elements at diverse effective ranges is dependant on an embodied understanding of the process of production
- o signifiers of craft are not to be confused with the original visual language which emerges only from the internalization of material
- o craft practice, objects and consumption are characterised by an undecidability of purpose and cultural placement. As such, they are unfixed and occupy a unique space between art and life.

Craft practitioners are used to experiencing stretches of time when goals seem to disappear, and are accustomed to operating on trust during these exploratory periods. This often goes unquestioned by the maker, but can unfortunately appear to other disciplines as a dangerously unfocused way of working, resulting in what appears to all intents and purposes an unacceptable level of post-rationalisation. In fact, most makers will attest to the importance of reflection-in-action to their craft, and by engaging with craft as a methodology in this way, the team intend to introduce rigour into the processes of making and research.

### **The Aeolia project – without design?**

The broad framework for the research has been provided by the project *Aeolia*, partly supported by an Alt-w award from New Media Scotland and driven by concepts of embodiment in wearable technology systems on the body (Alt-w 2009). A commercially available but academically under-documented fibre had been identified as a starting point for collaboration: this carbonised rubber cord, 2mm in diameter, changes its electrical properties when stretched, meaning it may be used in conjunction with a circuit to drive outputs such as light, sound or movement (Merlin Robotics 2010). The aim of the project was to bring a textile methodology to bear on the stretch sensor fibre through the interrogation of strategies for embedding it in weave, knit and embroidery fabrics, but limits to the material's functionality were quickly discovered however and have been reported elsewhere (Breedon et al 2008, Glazzard & Kettley 2009). More importantly though, the research aimed to establish an approach to testing aesthetic potential, and in the process learn more about what constitutes textile knowledge. Differences exist in conceptualisations of textile practice: craft very often takes the form of a concurrent, processual form of knowledge, and has been described as 'without design' (Wilson 2004). Kinor Jiang describes the influence of Junichi Arai in this respect, in his description of his role as 'textile creator' and not 'textile designer' (2010), differentiating between situated action and planning. However, characterising all textile practice in this way is misleading, and this project is providing the team with an opportunity to reflect on these preconceptions in action.



Figure 1  
the backs with Merlin stretch sensor  
l to r: embroidered, knitted, woven

*Aeolia* has generated two broad strands of investigation: ‘the backs’, which take the form of garment explorations designed to house the Merlin stretch sensor (figure 1), and the ‘cello garment’, which makes use of the team’s proprietary knitted stretch sensor, developed by Martha Glazzard (figure 2). These strands also illustrate different possible approaches to interaction design and wearable systems development, in that the backs have been generated entirely by an aesthetically led investigative process, while the cello garment was functionality driven.



figure 2  
the cello garment; fitting and performance  
Peter Gregson (cellist) and Yann Seznec (sound designer)

While the three backs, woven, knitted and embroidered, were part of an envisioned if open design process, the creation of the cello garment was driven by an unexpected invitation by New Media Scotland to create a functional wearable for performance at their tenth anniversary event. This presented the research group with an opportunity to explore output at an early stage – too early in fact to embed the latent knowledge being nurtured in the creation of the backs. Frustrated by the limitations of the pre-supplied rubber cord stretch sensor and inspired by the thought of making sensing fabric, Glazzard experimentally substituted conventional yarns for conductive yarns in knitted structures (figure 3). In this way she created knitted stretch sensors that were then incorporated into the functional garment prototype and worn by cellist, Peter Gregson. As Gregson stretched his arm to bow, changes in the length of the conductive path created distortions in the music (Glazzard and Kettley 2010).

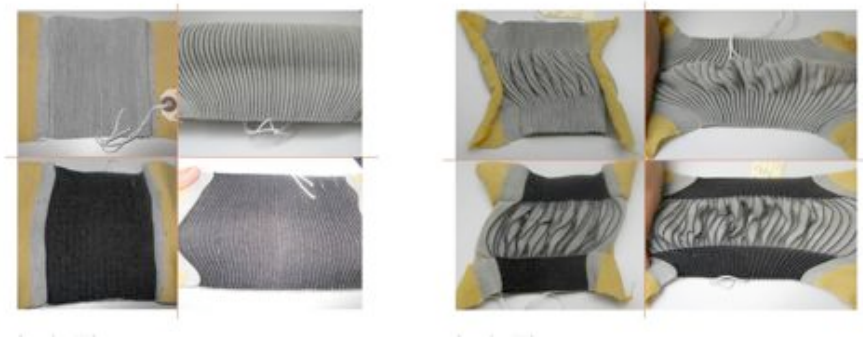


figure 3  
Martha Glazzard  
knitted stretch sensors

These strands in the project were realised by small groupings within the larger team. The functionally-led cello garment was driven by Kettley and Glazzard towards a performance deadline, with important fitting input from Karen Harrigan, while the backs were developed both individually in response to discussions with Kettley, and in a micro-collaboration between Downes and Harrigan. The paper now focuses on the latter interaction with the aim of drawing out what is meant by ‘textile knowledge’ before reflecting on the process of de-familiarisation that is necessary in creating contexts for new interdisciplinary practice.

### **Textile approaches - materiality and embodied knowledge**

With awareness of the interactive parameters of the Aeolia project, initial textile approaches set aside specific function of the outcome to explore the materiality of the textile interface and the stretch sensor with the body. Important considerations included how to integrate awkward, uncomfortable technologies seamlessly into a garment without causing irritation or restricting movement. Initial attempts by Glazzard and Marshall to knit and weave with the Merlin stretch sensor quickly revealed limitations, both functionally and aesthetically (Breedon *et al* 2008). The 2mm carbonised rubber cord snapped easily on

the loom and knitting machines, returned unexpected and unpredictable electrical readings as the cord looped tightly at the end of each row of construction and the fabric handle proved stiff and heavy. Although there was no defined use for the rubber sensor fabric at this stage, neither did its fabric construction suggest new ideas about its potential application as is often the case in process led textile experimentation. This form of open-ended, playful experimentation with new materials is deemed vital for innovative practice and idea generation. Philosopher Martin Heidegger (1996) argues that we do not come to know the world initially through contemplation and perceptual cognition but through handling. Theoretical conception comes out of action, practice and hands on experience. In the paper *Materializing Pedagogies*, Bolt also suggests that applying theory to practice is a very different way of understanding the world, one that is grounded in the material: 'Material thinking is the magic of handling ... [it] offers us a way of considering the relations that take place within the very process or tissue of making' (2006, p.1). Material thinking involves the joining together of hand, eye and mind where the materials and processes of production have their own intelligence that come to play in the interaction with the practitioner's creative intelligence. In this iterative interplay, knowledge becomes embodied.



figure 4  
Tina Downes  
experimental embroidery samples  
incorporating rubber cord stretch sensor

What practitioners learnt about material responses through the process of making informed the next line of enquiry. The team felt that the stretch sensor fabric might prove more successful if integrated with other yarns or cloth to provide structural support, reduce snapping and increase handle. The idea of channels and threading became a new focus. The embroidery discipline provided methods to move away from the linear nature of constructed textiles with more freeform approaches. Downes' research enquiry centred on the interplay between stretch and static fabric with the cord stretch sensor. Selecting a knitted jersey and semi-transparent cotton organdie, Downes integrated the rubber cord using twin-needling, couching, pleating, stitched channels and lacing techniques (figure 4). In the development of wearables, technology is often hidden between layers of the garment (Seymour 2009). The team were motivated to find ways to make the sensor a visible part of the cloth and a considered part of the design

aesthetic. The fabric outcomes from this stage of development demonstrated that the rubber cord could be integrated into fabric with a more successful aesthetic and handle. However, the more complicated the inlay, the less reliable the conductive path became. This suggested that the stretch sensor would be best integrated along lines of stretch or resistance of the intended product rather than becoming a substantial part of the cloth itself.

### **Combining Fashion and Textile approaches: Situated collaborative practice**

At this stage, fashion designer Harrigan joined the team. She was initially bemused by the lack of clear product direction and less than impressed by the out-of-context rubber cord threaded into or couched onto fabric swatches. She asked questions about the intended functionality of the stretch sensor. What would it do? How was it used? What was it for? Why did we want it to be visible? It was not attractive and the rubber brought with it certain connotations in a fashion context that did not apply in the robotics industry. Interestingly, discussing ways to progress highlighted differences in approaches to design practice and started a process of dismantling and justifying our methods to each other. Whilst textile designers felt familiar with an open ended, experimental design methodology – let us test how the fabric drapes, moves, feels, looks if we combine this cord with this yarn with this process – our fashion practitioner preferred to work towards a product context. How else could its success or failure be defined? Without knowing more about its intended function, how could the design process even begin?

Making use of internal research funding to buy out sixty hours from their teaching schedule during the academic year 2008-09, Downes and Harrigan discussed starting points for a textile and fashion collaboration. Although it was not a foregone conclusion to work on the body rather than within an architectural context, it made sense to make use of Harrigan's expertise in creative pattern cutting. Analysing the properties of the rubber cord sensor implied the necessity for some degree of movement for interaction to occur. Both examined streamlined designs of stretch sports garments, considered existing wearable concepts for capturing biological data from the body, noted many as yet unsolved design problems that would provide useful foci and create more defined context for collaboration (Braddock Clarke & O'Mahoney 2002, Butterfield 2009, Institute of Nanotechnology 2009). Hogarth's (2003) dynamic anatomy provided reference for visual analysis of lines of stretch and resistance on the body. Specifically, muscle and tendon structure of the male torso suggested the power and dynamism required to activate the stretch sensor (figure 5).



figure 5  
developing visual resources for pattern cutting

During these early stages Downes' and Harrigan's conversations were tentative and a little awkward. They had never worked together and knew nothing of each other's approaches to design. They were trying to create a common referential framework in which participation could take place. This was not an overt discussion point, more a sense of trying to find places where their practices could connect and become meaningful to them both. Initially short meetings would take place, ideas were discussed and the participants went away to practice individually. Lave and Wenger (1991) state that it is the common ability to co-participate that provides the matrix for learning, rather than the commonality of symbolic or referential structures. Rather than asking what kind of individual cognitive processes and conceptual structures are involved, Lave and Wenger focus on what kind of social engagements provide the proper context for learning to take place. It was only when Downes and Harrigan bought their *practice* together that the collaboration moved onto another level altogether.



figure 6  
bringing practice together  
working on the stand

Located in the embroidery studio for a day, Harrigan arrived with a male mannequin stand, fine black bias tape and a simple stretch garment form in white jersey and pins. Downes came with a pile of embroidered samples that had been developed from drawings of the male muscle structure. This day was marked by the lack of awkwardness, the ease of communication and concurrence of aesthetic decision making. Armed with the tools of their trade, Harrigan and Downes worked around the stand pinning embroidered samples to the body and photographing different configurations (figure 6). The samples suggested ideas for placement, scale and detail on the body, developed thoughts about areas that would need to remain firm and static and lines where stretch and movement would be required. As is often stated, unexpected ideas arose unintentionally as they worked. For instance, uncut threads from manipulated pleats imitated lines of the muscle structure and the practitioners became intrigued by positive and negative shapes of the gaps between the samples. The next stage involved drawing directly onto the garment blank using tape and pins, using the visual reference of tendon and muscle lines. In this way a number of stretch patterns were devised which suggested lines where the stretch sensor could be incorporated. A noticeably large number of ideas were generated for one day of collaboration. Time passed very quickly. Practitioners were absorbed by their work and oblivious to the students that had gathered around to surreptitiously observe their actions. Often words were unnecessary, gesture and body language captured assent or dismissal of a line in the right or wrong place. Wenger (1998, p.48) says 'In practice, so called manual activity is not thoughtless, and mental activity is not disembodied'.

Eraut (1994) states one of the problems with practical knowledge which is gained through experience is that people find it hard to explain what they know. This is often because everyday actions and small nuances of practice are not always put into words or turned into recognizable forms of codified knowledge that appear in books. What is clear is that this method of engaging employs the whole person not just the cognitive faculties. As Harrigan and Downes worked together in the studio, they

were employing and sharing embodied knowledge. Both acknowledged the magic and serendipity of the day but found it hard to put into words exactly what happened. To work in this way required trust, openness, generosity and lack of ego. It would be hard to look back and take ownership of particular ideas. As befits a developing Community of Practice, these interactions developed understanding within a situated participation framework; the learning that occurred was distributed among the co-participants and moved firmly away from the paradigm of individual ownership.

### **Developing Context: external agency**

It is strange to do work and not own it or know what it means. In presenting developments to the wider team, the work became dislocated from the meaning framework Downes and Harrigan had jointly negotiated in order to practice. One of the problems with practicing asynchronously with dispersed participants is that tacit knowledge and meaning is easily lost (Kvan 2001). Much more emphasis must be placed on reconstructing the unspoken rationale for particular decisions so that adjustments can be made and alignment between other partner's contributions can be reached. To facilitate belonging to a community of practice, Wenger (1998) highlights the need for imagination to reflect and re-orientate; engagement to build competence, mutuality and continuity; and alignment to arbitrate and converge practices. In the early stages of building a design community it should therefore be expected to spend time building trust and expanding world views as there is much to be learned from differences in approach.

Wenger's (1998) research does not presume that full participation in a community of practice is always necessary or right. He refers to *constellations of practice* with some people acting as satellites between communities or having multiple group memberships. Research fellow Kettley acted as such, presenting opportunities to exhibit work in the new arena of Interaction Design. Kettley's prior knowledge of this discipline allowed her to identify concerns in interaction design theory and wearables practice about function at the expense of aesthetics and lack of materiality of the interface. Without this intervention the fashion and textile practitioners would not easily have identified the value of their material knowledge and integrated approach to design aesthetics in this new context. Kettley encouraged them to articulate the unspoken, implicit practices of their discipline in order to communicate with another. The interactive parameters of the Aeolia project proposal provided the focus for the next stage of development exploring bodily engagement with space and place through the use of 'body pieces' to record individuals' biological data. The eventual goal was to combine personal feedback with remote sensors located below, on and above a landscape highlighting the potential for different forms of engagement with the world. Combining the exploration of extension lines on the body that had already begun with the requirements of this brief, the three prototype garments were created which have since been exhibited in Edinburgh, London and Milan (Alt-w 2009, Industrial Trust 2009, British Consulate in Milan and Knowledge Transfer Network 2009). The carbon impregnated rubber stretch sensors were

integrated along the channels or seams mapped onto the body to notionally collect data or create output from muscle movement (Kettley & Briggs-Goode 2010).

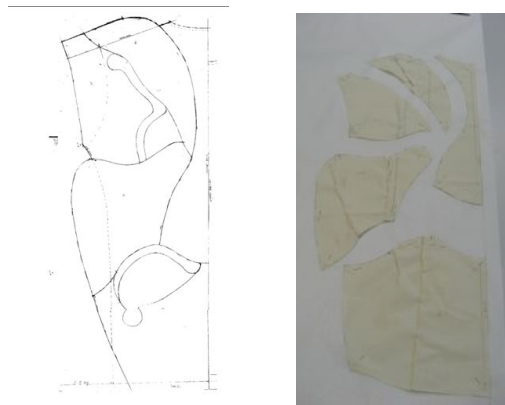


figure 7  
one-piece stretch pattern and traditional pattern segments

Each garment worked from the same draft, which was developed by Harrigan in two ways: as a one-piece stretch pattern and a traditional seamed pattern (Figure 7) (Downes & Harrigan 2009). The three garments explored different textile structures, separately drawing upon knit, weave and embroidery processes (Figures 8). Glazzard and Marshall each scanned the one-piece pattern draft and used specialist textile software to translate areas of the design into knit and weave structures. They not only synthesized visual and tactile qualities to create a strong aesthetic response to the flowing muscle and tendon lines that dissected the garment back, but also engineered knitted and woven structures to suitable levels of stretch and resistance to fit the body. Channels were integrated between the different structures to enable the stretch sensor to be threaded along lines of muscular resistance as defined by the pattern. It took several attempts to bring together so many complex factors and engineer fit of the one-piece knitted and woven constructions. In contrast, Downes worked with pattern segments using embroidery processes to embed cord onto the back of woven cloth. This created raised lines on the surface and used the qualities of the stretch sensor to visually reference the texture of muscle structure. The cloth suggested a fabric that could sense the body surface, not just the movement of the stretch sensor couched along carefully positioned seam lines. Kettley encouraged the practitioners to build knowledge in stages, working towards a meeting point with other disciplines; the garments explored an integrated approach to design aesthetics, fit and the materiality of the interface but have still to be attached to output.

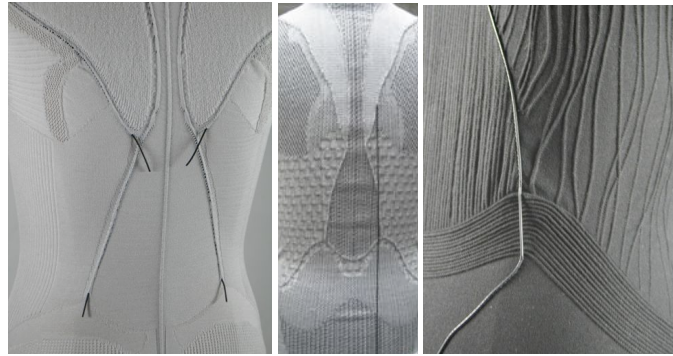


Figure 8  
knit and weave and embroidery  
back details

### **Reflecting on practice: a new confluence of conceptual directions**

A number of areas of interest have emerged from the practice so far. Certainly, the potential of further developing fabric stretch sensors using knit, weave or embroidery processes is evident. Further exploration of movement and restriction of garments on moving bodies rather than mannequin stands has revealed numerous possibilities for exploiting the differences in stiffness, softness, strength and flexibility between different textile structures. It suggests experimentation with fixed tectonic segments connecting to soft, flexible areas, possibly combining knitted, woven and embroidered structures. In terms of fit, the practitioners are becoming intrigued by the notion of seams and gaps between the segments of the pattern pieces (Kettley et al 2010). They wish to explore the notion of the seams becoming the garment itself, or conversely, working on whole pieces of cloth that can be fitted to the body through structural manipulation of the gaps. This has particular resonances with the wearables literature, which has been dealing with conceptual notions of seamlessness and seamfulness over the past few years with reference to users' creativity in working around less than perfect integrations of technology (Chalmers et al 2003), and the way technology is used covertly in social situations (Galloway 2004). Kettley has previously analysed wearables for their seamfulness in terms of craft and meaning making (2004), and so is excited to see concepts and action coming together in this way.

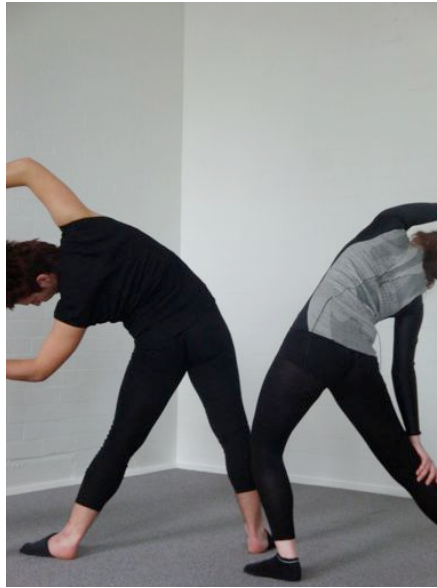


figure 9  
early exploration with movement

Work with the cellist and a number of dancers has also shifted the examination of movement and stretch lines from down the spine and across the shoulder blades to across the back, chest and down the arms for greater expressive potential (figure 9). A call for movement and dance practitioners to engage in the first exploration with the backs resulted in a number of researchers at other institutions expressing interest in contributing and developing theoretical knowledge through the project in the future, which would take the work in exciting new research directions.

This project has sought to answer concerns with materiality and presence as outlined previously through the textile practitioners' depth of material knowledge and their ability to manipulate fabric structures to the required levels of handle, weight, drape, stiffness, softness, and flexibility. We have shown that the processual knowledge of quite specific practices can be combined to great effect, exploiting the differences between embroidery, knit and weave knowledge. In working on the functional garments in the other strand of the project, we will also be able to reflect on the combination of such processual knowledge with designerly ways of working, including foregrounding function while striving for aesthetically successful outcomes.

### **Conclusion – creating contexts for interdisciplinary growth**

Much of the value in crafted objects is attributable to the mystery of the process, a commoditisation of expertise, risk and commitment. To the textile makers in *Aeolia*, situated within established and identifiable practices, the first unexpected challenge was in the removal of that automatic mechanism of

value creation. Each of the participants knew there was value in what they did, in their knowledge and engagement with material, but to articulate that to another domain was very hard. The languages used to communicate such values vary from community to community, and one of the biggest tasks in creating contexts for interdisciplinary work is the negotiation of those gaps in meaning and the establishing of confidence in each other's motivations and support.

In order to do this, practitioners have to first step back from the very actions that give rise to value. There has to be a period where the utterly familiar is made strange, otherwise the process of negotiation of meaning cannot begin. Familiar practice has to be de-familiarised, deconstructed, before the first steps towards a new praxis can be taken. This is making strange as an exercise in rendering phenomenological design activity visible once again – a meta-level of reflection in practice. It is reflection not just on the material, but on the whole practice at hand – the tools, the philosophies and the processes, and through the detailed accounts in this paper we have attempted to demonstrate how this is currently taking place in *Aeolia*.

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